

WHAT IS CLAIMED IS:

1. A multicast communication path  
5 calculation method for obtaining multicast paths  
from a given source node to a plurality of  
destination nodes in a network including a plurality  
of nodes, the method comprising the steps of:  
obtaining minimum delay paths from the  
10 source node to each of the destination nodes by  
using topology information and delay information of  
the network;  
selecting, as candidate nodes of a  
rendezvous point node, nodes on one of the obtained  
15 minimum delay paths;  
for each of the candidate nodes,  
calculating minimum delay paths from the candidate  
node to each of the destination nodes, and obtaining  
a difference between the maximum value and the  
20 minimum value among delays of the calculated minimum  
delay paths;  
selecting, as the rendezvous point node,  
the candidate node for which the difference is  
smallest among differences for all of the candidate  
25 nodes; and  
outputting, as the multicast paths, a  
minimum delay path from the source node to the  
rendezvous point node and minimum delay paths from  
the rendezvous point node to each destination node.  
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2. The multicast communication path  
35 calculation method as claimed in claim 1, wherein  
the minimum delay path on which the candidate nodes  
exist is one having maximum delay among minimum

delay paths from the source node to each of the destination nodes.

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3. A multicast communication path setting method, wherein a multicast communication path calculation apparatus calculates multicast paths  
10 from a given source node to a plurality of destination nodes in a network including a plurality of nodes, and a multicast communication path setting apparatus establishes the calculated multicast paths on the network, wherein the multicast communication  
15 path setting apparatus sends a request to calculate the multicast paths to the multicast communication path calculation apparatus, and the multicast communication path calculation apparatus calculates the multicast paths according to the request by  
20 using a method comprising the steps of:

obtaining minimum delay paths from the source node to each of the destination nodes by using topology information and delay information of the network;

25 selecting, as candidate nodes of a rendezvous point node, nodes on one of the obtained minimum delay paths;

for each of the candidate nodes,  
calculating minimum delay paths from the candidate  
30 node to each of the destination nodes, and obtaining a difference between the maximum value and the minimum value among delays of the calculated minimum delay paths;

selecting, as the rendezvous point node,  
35 the candidate node for which the difference is smallest among the differences for all of the candidate nodes; and

outputting results comprising, as the  
multicast paths, a minimum delay path from the  
source node to the rendezvous point node and minimum  
delay paths from the rendezvous point node to each  
5 destination node,

wherein the multicast communication path  
calculation apparatus sends the output results to  
the multicast communication path setting apparatus,  
and the multicast communication path setting  
10 apparatus establishes the multicast paths according  
to the output results.

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4. The multicast communication path  
setting method as claimed in claim 3, wherein each  
node in the network measures traffic state of the  
network and sends the measurement results to the  
20 multicast communication path calculation apparatus,  
and

the multicast communication path  
calculation apparatus calculates the multicast paths  
according to the measurement results.  
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5. A multicast communication path  
30 calculation apparatus for obtaining multicast paths  
from a given source node to a plurality of  
destination nodes in a network including a plurality  
of nodes, the apparatus comprising:

a part for obtaining minimum delay paths  
35 from the source node to each of the destination  
nodes by using topology information and delay  
information of the network;

a part for selecting, as candidate nodes of a rendezvous point node, nodes on one of the obtained minimum delay paths;

5 a part for calculating, for each of the candidate nodes, minimum delay paths from the candidate node to each of the destination nodes, and obtaining, for each of the candidate nodes, a difference between the maximum value and the minimum value among delays of the calculated minimum delay  
10 paths;

a part for selecting, as the rendezvous point node, the candidate node for which the difference is smallest among the differences for all of the candidate nodes; and

15 a part for outputting results comprising, as the multicast paths, a minimum delay path from the source node to the rendezvous point node and minimum delay paths from the rendezvous point node to each of the destination nodes.

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6. The multicast communication path  
25 calculation apparatus as claimed in claim 5, wherein the minimum delay path on which the candidate nodes exist is one having maximum delay among minimum delay paths from the source node to each of the destination nodes.

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7. The multicast communication path  
35 calculation apparatus as claimed in claim 5, further comprising:

a part for receiving the topology

information and the delay information of the network; and

a part for storing the received information in a recording medium,

5            wherein the multicast communication path calculation apparatus calculates the multicast paths by reading the received information from the recording medium.

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8. The multicast communication path calculation apparatus as claimed in claim 5, further  
15   comprising a part for including the output results in a multicast path setting control message, and sending the multicast path setting control message over the multicast paths indicated by the output results.

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9. The multicast communication path calculation apparatus as claimed in claim 5, further  
25   comprising:

a part for receiving a request to calculate the multicast paths from a multicast communication path setting apparatus; and

30            a part for sending the output results to the multicast communication path setting apparatus.

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10. A computer program for causing a multicast communication path calculation apparatus

to calculate multicast paths from a given source node to a plurality of destination nodes in a network including a plurality of nodes, the computer program comprising:

5           program code means for obtaining minimum delay paths from the source node to each of the destination nodes by using topology information and delay information of the network;

          program code means for selecting, as  
10 candidate nodes of a rendezvous point node, nodes on one of the obtained minimum delay paths;

          program code means for calculating, for each of the candidate nodes, minimum delay paths from the candidate node to each of the destination  
15 nodes, and obtaining, for each of the candidate nodes, a difference between the maximum value and the minimum value among delays of the calculated minimum delay paths;

          program code means for selecting, as the  
20 rendezvous point node, the candidate node for which the difference is smallest among the differences for each of the candidate nodes; and

          program code means for outputting results comprising, as the multicast paths, a minimum delay  
25 path from the source node to the rendezvous point node and minimum delay paths from the rendezvous point node to each of the destination nodes.

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11. The computer program as claimed in claim 10, wherein the minimum delay path on which the candidate nodes exist is one having maximum  
35 delay among minimum delay paths from the source node to each of the destination nodes.

12. A computer readable medium storing  
5 program code for causing a multicast communication  
path calculation apparatus to calculate multicast  
paths from a given source node to a plurality of  
destination nodes in a network including a plurality  
of nodes, the computer readable medium comprising:  
10 program code means for obtaining minimum  
delay paths from the source node to each of the  
destination nodes by using topology information and  
delay information of the network;  
program code means for selecting, as  
15 candidate nodes of a rendezvous point node, nodes on  
one of the obtained minimum delay paths;  
program code means for calculating, for  
each of the candidate nodes, minimum delay paths  
from the candidate node to each of the destination  
20 nodes, and obtaining, for each of the candidate  
nodes, a difference between the maximum value and  
the minimum value among delays of the calculated  
minimum delay paths;  
program code means for selecting, as the  
25 rendezvous point node, the candidate node for which  
the difference is smallest among the differences for  
all of the candidate nodes; and  
program code means for outputting results  
comprising, as the multicast paths, a minimum delay  
30 path from the source node to the rendezvous point  
node and minimum delay paths from the rendezvous  
point node to each of the destination nodes.

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13. The computer readable medium as

claimed in claim 12, wherein the minimum delay path on which the candidate nodes exist is one having maximum delay among minimum delay paths from the source node to each of the destination nodes.

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14. A multicast communication path  
10 calculation method for obtaining multicast paths from a given source node to a plurality of destination nodes in a network including a plurality of nodes, the method comprising the steps of:  
receiving a distance graph including  
15 topology and cost of the network;  
establishing a first distance subgraph in which the source node is deleted from the received distance graph;  
selecting the destination nodes from the  
20 first distance subgraph, obtaining a second distance subgraph in which each edge is a shortest path between two of the destination nodes, and establishing a first minimal spanning tree of the second distance subgraph;  
25 establishing a subgraph of the first minimal spanning tree by including intermediate nodes in each of the edges of the first minimal spanning tree, and establishing a second minimal spanning tree of the subgraph;  
30 deleting unnecessary edges from the second minimal spanning tree so that a tree including the destination nodes is established;  
assuming that nodes that form the tree are candidate nodes of a rendezvous point node,  
35 obtaining, for each of the candidate nodes, a difference between the maximum distance and the minimum distance among distances between the



candidate node and each of the destination nodes,  
and selecting, as the rendezvous point node, the  
candidate node for which the difference is smallest;  
and

5                   obtaining the multicast paths by  
connecting the tree and the source node at the  
rendezvous point node, and outputting the multicast  
paths.

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15                   15. A multicast communication path setting  
method, wherein a multicast communication path  
calculation apparatus calculates multicast paths  
from a given source node to a plurality of  
destination nodes in a network including a plurality  
of nodes, and a multicast communication path setting  
apparatus establishes the calculated multicast paths  
20 on the network, wherein the multicast communication  
path setting apparatus sends a request to calculate  
the multicast paths to the multicast communication  
path calculation apparatus, and the multicast  
communication path calculation apparatus calculates  
25 the multicast paths according to the request by  
using a method comprising the steps of:

                  reading a distance graph including  
topology and cost of the network;

                  establishing a first distance subgraph in  
30 which the source node is deleted from the received  
distance graph;

                  selecting the destination nodes from the  
first distance subgraph, obtaining a second distance  
subgraph in which each edge is a shortest path  
35 between two of the destination nodes, and  
establishing a first minimal spanning tree of the  
second distance subgraph;

establishing a subgraph of the first  
minimal spanning tree by including intermediate  
nodes in each of the edges of the first minimal  
spanning tree, and establishing a second minimal  
5 spanning tree of the subgraph;

deleting unnecessary edges from the second  
minimal spanning tree so that a tree including the  
destination nodes is established;

assuming that nodes that form the tree are  
10 candidate nodes of a rendezvous point node,  
obtaining, for each of the candidate nodes, a  
difference between the maximum distance and the  
minimum distance among distances between the  
candidate node and each of the destination nodes,  
15 and selecting, as the rendezvous point node, the  
candidate node for which the difference is smallest;  
and

obtaining the multicast paths by  
connecting the tree and the source node at the  
20 rendezvous point node, and outputting results  
comprising the multicast paths,

wherein the multicast communication path  
calculation apparatus sends the output results to  
the multicast communication path setting apparatus,  
25 and the multicast communication path setting  
apparatus establishes the multicast paths according  
to the output results.

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16. The multicast communication path  
setting method as claimed in claim 15, wherein each  
of the nodes in the network measures traffic state  
35 of the network and sends the measurement results to  
the multicast communication path calculation  
apparatus, and

the multicast communication path calculation apparatus calculates the multicast paths according to the measurement results.

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17. A multicast communication path calculation apparatus for obtaining multicast paths from a given source node to a plurality of destination nodes in a network including a plurality of nodes, the apparatus comprising:

10 a part for receiving a distance graph including topology and cost of the network;

15 a part for establishing a first distance subgraph in which the source node is deleted from the received distance graph;

a part for selecting the destination nodes from the first distance subgraph, obtaining a second distance subgraph in which each edge is a shortest path between two of the destination nodes, and establishing a first minimal spanning tree of the second distance subgraph;

20 a part for establishing a subgraph of the first minimal spanning tree by including intermediate nodes in each of the edges of the first minimal spanning tree, and establishing a second minimal spanning tree of the subgraph;

25 a part for deleting unnecessary edges from the second minimal spanning tree so that a tree including the destination nodes is established;

30 a part for, assuming that nodes that form the tree are candidate nodes of a rendezvous point node, obtaining, for each of the candidate nodes, a difference between the maximum distance and the minimum distance among distances between the candidate node and each of the destination nodes,

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and selecting, as the rendezvous point node, the candidate node for which the difference is smallest; and

5 a part for obtaining the multicast paths by connecting the tree and the source node at the rendezvous point node, and outputting results comprising the multicast paths.

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18. The multicast communication path calculation apparatus as claimed in claim 17, further comprising:

15 a part for receiving the topology information and the delay information of the network; and

a part for storing the received information in a recording medium,

20 wherein the multicast communication path calculation apparatus calculates the multicast paths by reading the received information from the recording medium.

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19. The multicast communication path calculation apparatus as claimed in claim 17, further comprising a part for including the output results in a multicast path setting control message, and sending the multicast path setting control message over the multicast paths indicated by the output results.

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20. The multicast communication path calculation apparatus as claimed in claim 17, further comprising:

- 5           a part for receiving a request to calculate the multicast paths from a multicast communication path setting apparatus; and
- a part for sending the output results to the multicast communication path setting apparatus.

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21. A computer program for causing a  
15 multicast communication path calculation apparatus to calculate multicast paths from a given source node to a plurality of destination nodes in a network including a plurality of nodes, the computer program comprising:

- 20           program code means for receiving a distance graph including topology and cost of the network;

          program code means for establishing a first distance subgraph in which the source node is  
25 deleted from the received distance graph;

          program code means for selecting the destination nodes from the first distance subgraph, obtaining a second distance subgraph in which each edge is a shortest path between two of the  
30 destination nodes, and establishing a first minimal spanning tree of the second distance subgraph;

          program code means for establishing a subgraph of the first minimal spanning tree by including intermediate nodes in each of the edges of  
35 the first minimal spanning tree, and establishing a second minimal spanning tree of the subgraph;

          program code means for deleting

unnecessary edges from the second minimal spanning tree so that a tree including the destination nodes is established;

5       program code means for, assuming that  
nodes that form the tree are candidate nodes of a  
rendezvous point node, obtaining, for each of the  
candidate nodes, a difference between the maximum  
distance and the minimum distance among distances  
between the candidate node and each of the  
10 destination nodes, and selecting, as the rendezvous  
point node, the candidate node for which the  
difference is smallest; and

      program code means for obtaining the  
multicast paths by connecting the tree and the  
15 source node at the rendezvous point node, and  
outputting the multicast paths.

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22. A computer readable medium storing  
program code for causing a multicast communication  
path calculation apparatus to calculate multicast  
paths from a given source node to a plurality of  
25 destination nodes in a network including a plurality  
of nodes, the computer readable medium comprising:

      program code means for receiving a  
distance graph including topology and cost of the  
network;  
30       program code means for establishing a  
first distance subgraph in which the source node is  
deleted from the received distance graph;

      program code means for selecting the  
destination nodes from the first distance subgraph,  
35 and obtaining a second distance subgraph in which  
each edge is a shortest path between two of the  
destination nodes, and establishing a first minimal

spanning tree of the second distance subgraph;

program code means for establishing a  
subgraph of the first minimal spanning tree by  
including intermediate nodes in each of the edges of  
5 the first minimal spanning tree, and establishing a  
second minimal spanning tree of the subgraph;

program code means for deleting  
unnecessary edges from the second minimal spanning  
tree so that a tree including the destination nodes  
10 is established;

program code means for, assuming that  
nodes that form the tree are candidate nodes of a  
rendezvous point node, obtaining, for each of the  
candidate nodes, a difference between the maximum  
15 distance and the minimum distance among distances  
between the candidate node and each of the  
destination nodes, and selecting, as the rendezvous  
point node, the candidate node for which the  
difference is smallest; and

20 program code means for obtaining the  
multicast paths by connecting the tree and the  
source node at the rendezvous point node, and  
outputting the multicast paths.

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